VOLUME XXII NUMBER 3 WHOLE NUMBER 172

THE JOURNAL

OF

THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

DEVOTED TO THE ADVANCEMENT OF ASTRONOMY AND ALLIED SCIENCES

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THE JOURNAL
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ROYAL ASTRONOMICAL SOCIETY OF CANADA

VOL. XXII, No. 3. MARCH, 1928 WHOLE No. 172

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FOR SALE

Telescope, 3-inch "Century" by Watson, London, Eng.; 2 celestial, 1 terrestrial, eyepieces. In box, with mahogany tripod. Enquire W. G. McMillan, 64 Howland Ave., Toronto. Trinity 2283.

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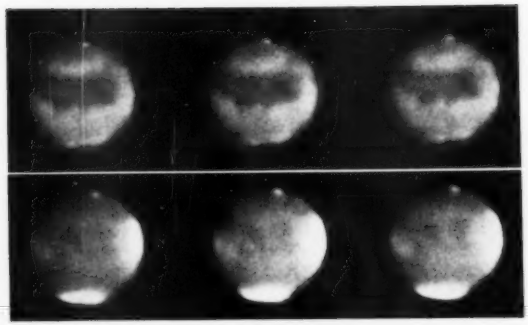
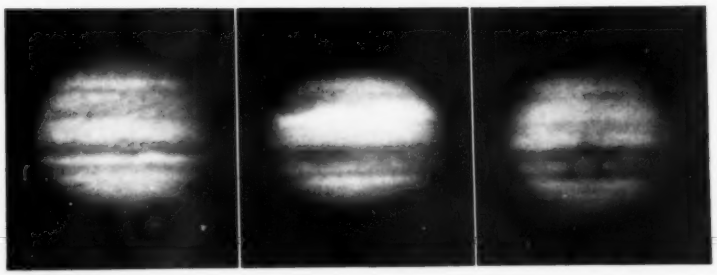
Transit Instrument, by Troughton and Simms, aperture 1¾ inches. Enquire A. L. Waddell, 199 Avenue Road, Toronto.

PLATE VII





Nov. 25, 1916 (Yellow) Oct. 9, 1927 (Blue) Oct. 9, 1927 (Red)

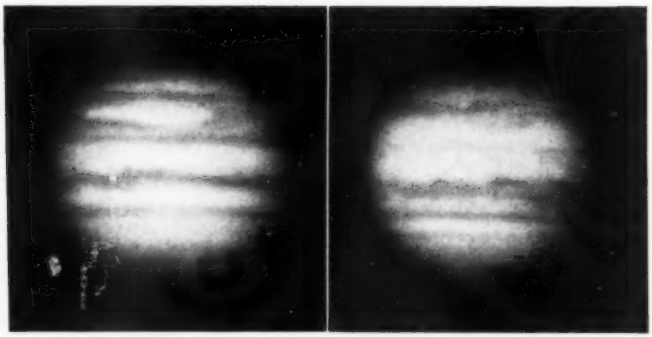
PHOTOGRAPHS OF THE PLANETS (By E. C. Slipher)

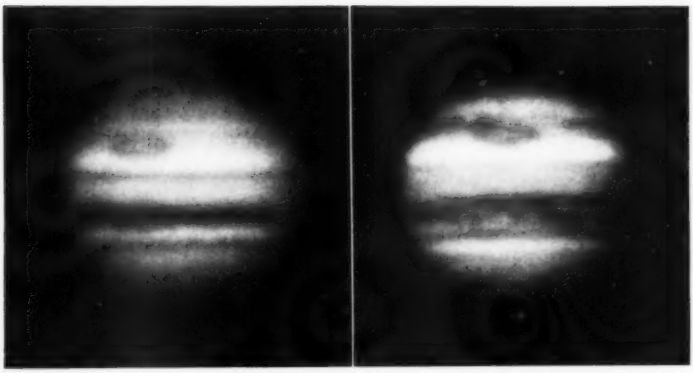
Top—MARS, upper row in yellow light, lower in blue light.
Middle—SATURN, in yellow, blue, red light (from left to right).
Bottom—JUPITER, in yellow, blue, red light (from left to right).

(See accompanying explanation and page 104)

PLATE VIII

Dec. 19, 1927 Nov. 19, 1927





Nov. 25, 1926 Nov. 26, 1927

PHOTOGRAPHS OF JUPITER (By E. C. Slipher)

In yellow light (above) and blue light (below)

(See accompanying explanation and page 104)

Photographs of the Planets made by E. C. Slipher at the Lowell Observatory

See also Plates V and VI in last Issue

Description of Plates VII and VIII

Plate VII

MARS, 1926

in Yellow and Blue Light

Top.—The three photographs in the upper row were made solely from yellow light, while those in the lower row were made at the same time from blue light. The yellow light shows the surface markings more clearly than does the blue light; while the latter shows the northern (lower) polar cap and the bright area at the right (sunrise) edge prominently. At least part of the obvious difference between the two sets of photographs is produced by atmosphere on Mars. The larger and brighter north cap (below) shown in the blue pictures betokens the existence in its atmosphere there of a light-scattering medium which is intimately related to the forming winter cap.

SATURN, March 24, 1927

in Yellow, Blue and Red Light

Middle.—The ball appears distinctly dark as compared to the rings in the blue-violet light photographs, much less so in the yellow light, while the ball and rings "B" are of about the same brightness in the yellow light. The crape ring is dark across the ball in the red and yellow, while in the blue-violet it is bright. In the blue-violet the pole and equator are especially dark. The dark 'sash' across the equator seems due to the visible dark tropical belt in the yellow tint in the otherwise bright equatorial band.

JUPITER

in Yellow, Blue and Red Light

Bottom.—The yellow photograph (1926) shows the same longitude as those of 1927. Note the great change in the south tropical belt. The blue and red filter photographs, taken a few minutes apart on October, 9, 1927, show marked differences. Note especially the greater brightness of the south tropical belt and the darkness of the equator in the blue images and the showing of the wisp-light detail of the equator in the red images. The great red spot which appears very dark on the photographs shows as only a bare outline in the red ones. Much of this difference seems due to the colour tone of the markings, the reddish markings photographing dark on the blue photographs and the blue photographing bright, while the reverse is true in the case of the red photographs.

Plate VIII

JUPITER

in Yellow and Blue Light

Upper.—Yellow light photographs of the same longitude of the planet showing changes in the belts, especially in the south tropical region which has become as bright as the equator. The great red spot is at the centre of the disc. Compare these with the blue photographs below, of the same longitude in 1926 and 1927.

Lower.—Blue-light photographs taken a year apart displaying the region about the great red spot. Note the changes in the belts and that the great red spot differs in form and size on the two dates, being longer on the latter one.

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ANNUAL GENERAL MEETING OF THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

The Meeting was held on the evening of January 18 in the Physics Building of the University, Mr. A. F. Hunter, the President, in the chair.

The Minutes of the last Annual Meeting were taken as read.

The General Secretary, Mr. L. Gilchrist, presented his report, which was approved.

The Financial Statement as prepared by Mr. H. W. Barker, the General Treasurer, was read and approved.

The Librarian's Report was presented and approved.

Mr. R. S. Duncan, the Curator, gave a review of the use made of the telescopes and slides of the Society.

The President stated that the ballots for the annual election of officers had been sent to the members by mail. The returns were on the table, and he asked for the appointment of scrutineers to count the ballots. Dr. J. B. Fraser and Miss E. M. Budd were nominated, and proceeded to do the work while the meeting was in progress.

Mr. A. F. Miller moved a vote of thanks to the officers of the Society for the past year. This was unanimously approved by the meeting.

Mr. A. R. Hassard and Dr. J. B. Fraser were appointed by the Meeting to act as auditors for the coming year.

The Society is the possessor of a Victory Bearer Bond. It was suggested that this bond be registered. The Meeting, however, referred the matter to Council.

Dr. Fraser announced for the scrutineers the result of the election as follows:

Honorary President—J. S. Plaskett, B.A., D.Sc., F.R.S., Victoria, B.C.
President—W. E. Harper, M.A., Victoria, B.C.
First Vice-President—R. K. Young, Ph.D., Toronto.
Second Vice-President—Mgr. C. P. Choquette, M.A., Lic.Scs., Montreal.
General Secretary—Lachlan Gilchrist, M.A., Ph.D., Toronto.
General Treasurer—H. W. Barker, Toronto.
Recorder—E. J. A. Kennedy, Toronto.
Librarian—C. A. Chant, M.A., Ph.D., Toronto.
Curator—R. S. Duncan, Toronto.
Council—R. E. DeLury, M.A., Ph.D., Ottawa; Miss A. Vibert Douglas, Ph.D., Montreal; John Satterly, M.A., D.Sc., Toronto; J. A. Pearce, M.A., Victoria, B.C.; Ernest A. Hodgson, M.A., Ottawa; L. A. H. Warren, M.A., Ph.D., Winnipeg; Rev. Dr. D. B. Marsh, Jarvis, Ont.; E. T. White, D.Paed., London, Ont.; J. H. Horning, M.A., Toronto; Col. W. E. Lyman, Montreal.

The President, after making some fitting remarks on the work of the Society during the past four years, adjourned the Meeting.

E. J. A. Kennedy,
Recorder.

Membership of the Society

The reports by the General Officers and from the different Centres of the Society follow.

The Membership on December 31st, 1927, was as follows:

	1927	1926
Toronto, City Members	105	103
Toronto, Outside Members	155	146
Ottawa Centre	65	62
Winnipeg Centre	48	50
Montreal Centre	117	104
Victoria Centre	84	64
London, Ont., Centre	40	42
	614	571
Life Members	14	12
Honorary Fellows	12	12
Other Subscribers to Journal	31	
	671	

E. M. Budd,
Assistant Secretary.

MEETINGS AT TORONTO, 1927

The following papers and addresses were read or delivered at the meetings in Toronto during 1927:

Feb. 1—Professor N. E. Sheppard—The Mechanism of the Solar System.
Feb. 15—Sir Frederic Stupart—Northern Anti-cyclones.
Mar. 1—R. A. Gray, B.A.—How to paint a Solar Eclipse.
Mar. 15—Professor John Satterly—Measurement of High Temperatures by Radiation.
Mar. 29—John Patterson, M.A., F.R.S.C.—Solar Radiation and the Weather.
Apr. 12—Professor L. Gilchrist—Measurements of Stellar and Molecular Magnitudes.
Apr. 26—Professor R. K. Young—The Making of a Reflecting Telescope.
May 10—Open Air Meeting on the University Campus with Telescopes.
Oct. 18—A. F. Hunter, M.A. (Inaugural Address)—Some Advances During the Past Year in Astronomy and its Allied Subjects.
Nov. 1—A. R. Hassard, LL.B.—Summer Observations.
Professor C. A. Chant—An Introduction to Astronomy, Part I.
Nov. 15—Professor C. A. Chant—An Introduction to Astronomy, Part II. The Planetary System as a Whole; the Sun; the Moon. Part III—The Planets, one by one; Comets; Meteors.
Nov. 29—Professor A. P. Coleman—The Relations of Ice Ages to Astronomy.
Dec. 13—Mr. P. M. Millman—A Summer at the Astrophysical Observatory, Victoria, B.C.
Professor C. A. Chant—The Universe of Stars (Part IV—Introduction to Astronomy).

These lectures and papers were finely illustrated by lantern pictures and other exhibits.

There has been a notable improvement in the attendance of members and others at these meetings.

OTTAWA—REPORT OF SECRETARY

During the past season public lectures were given in the Auditorium of the Museum by Past President R. M. Stewart, Sounding the Universe; by the President, Dr. Ami, Geology and Astronomy; by Miss A. Vibert Douglas, Ph.D., of McGill University, Newton's Centenary; by Dr. Henroteau, The Strange Companion of Sirius a New Verification of the Einstein Theory; and on November 25th by the President, Dr. Ami, on the Eclipse of the Sun, June, 1927, and by Dr. DeLury on the Sun Spots of 1927.

A soiree was arranged and held in the Observatory in March,

1927, when a most enjoyable and interesting evening was spent under the direction of the Observatory officials.

A supply of membership application forms was secured from Toronto and distributed to members of Council.

In a letter from the Montreal Centre the advantages to be derived from outside lectures was suggested and the Secretary was instructed to reply that this Centre would be glad to co-operate with Montreal, and to ask them to ascertain what arrangements could be made to bring some prominent American astronomer to Canada.

The following new members have been added to the Society since the last Annual Meeting:

Miss Hamilton, Miss S. Seeley, Mrs. Homer Dixon, Messrs. J. C. Guthrie, W. J. Sykes, John Cawthray; and Messrs. Douglas Barlow, M.A., and Louis N. Richard's names have been read in open meeting and are now eligible for election. Miss Burland, a member of Montreal Centre, desires to affiliate with Ottawa Centre.

A. H. HAWKINS,
Secretary.

LONDON—REPORT OF SECRETARY

The year 1927 was a successful one for the London Centre of the R.A.S.C. The regular monthly meetings were well attended and good interest was shown by the members in the study of astronomy. During the year addresses on the following topics were given: The Northern Skies; The Day, the Month, and the Year; Stars and Planets of Spring; Astrology; Autumn and Winter Skies. A very significant feature at the meetings was the discussion which followed the addresses. Two observation meetings were held during the year—one in May at Port Stanley, when the members were the guests of Mrs. Boughner and Mrs. Richardson, and one in November, from the roof of the New London Life Building. It is with deep regret that we report the death of two members, Mrs. J. C. Middleton and Mrs. Geo. Reid.

E. T. WHITE,
Secretary.

MONTREAL—REPORT OF SECRETARY

During the 1926-27 season seven public lectures were held. The subjects and lecturers were as follows:

Dr. H. T. Barnes, F.R.S., McGill University,
Phenomena of the Sunrise.
Dr. R. E. DeLury, Dominion Observatory,
The Sun and Some of its Problems.
Dr. W. J. Luyten, Harvard Observatory,
The Structure of the Universe (Joint meeting with the McGill Chapter of Sigma Xi).
Mgr. C. P. Choquette, St. Hyacinth,
Dettes Mutuelles de L'Astronomie et de la Physique.
Professor A. H. S. Gillson, McGill University,
The Earth.
Mr. R. Meldrum Stewart, Dominion Observatory,
Sounding the Universe.
Professor A. H. S. Gillson, McGill University,
Newton Commemoration Lecture (Joint meeting with the McGill Chapter of Sigma Xi).

During the year thirty-six new members were elected. The Society suffered the loss by death of one of its original members, Rev. W. T. B. Crombie. He had held the positions of Secretary and of President, and at the time of his death was Vice-President of the Montreal Centre. He was a keen mathematician, taking much interest in the calculation of orbits, etc. Amateur astronomy is the poorer by his death.

The membership at the close of the 1926-27 session was 117.

A. VIBERT DOUGLAS,
Secretary.

WINNIPEG—REPORT OF SECRETARY

During the year 1927 the Society held seven regular meetings in the University of Manitoba.

A special meeting was held on the 17th of May, when the Winnipeg Centre had the honour of being addressed by Dr. J. S. Plaskett of Victoria, whose subject was "The Galaxy and Beyond."

Executive meetings were held on three occasions at the residence of the President, Mrs. E. L. Taylor.

The dates of the regular meetings, the lectures and the subjects of the lectures were as follows:

Jan. 12—Dr. R. C. Wallace—Facts and Fancies about the Interior of the Earth and the Heavenly Bodies.
Feb. 4—Dr. L. A. H. Warren—Evolution of Worlds.
Mar. 9—Mr. D. R. P. Coats—Richard Anthony Proctor, his Life and Works.
Apr. 13—Mr. Bastin—Kepler.
Mr. Kolb—Antares.
Mr. Meggett—A Plea for a better knowledge of the Stars.
Mr. Saunders—The Reflecting Telescope.
Oct. 26—Observations of the Starry Skies under the leadership of Mr. A. W. Meggett and Mr. D. Saunders, and Social Evening.
Nov. 9—The Right Rev. T. W. Morton—The Moon.
Dec. 14—Mrs. E. L. Taylor—The Splendour of the Skies and what the Great Telescopes reveal.

These meetings were open to the public and were well attended.

The annual meeting was held on the 14th of December, when the officers for 1928 were elected as follows:

President, Mrs. E. L. Taylor; *Vice-President*, Dr. L. A. H. Warren; *Treasurer*, Mr. David Saunders; *Secretary*, Mrs. J. Norris; *Assistant Secretary*, Mr. C. F. Ellis; *Council*, Mr. C. E. Bastin, Mr. J. H. Kolb, Dr. N. J. MacLean, Mr. A. W. Meggett, Rt. Rev. T. W. Morton, Mr. L. J. Reycraft, Mr. Cecil Roy.

S. C. Norris,
Secretary.

VICTORIA—REPORT OF SECRETARY

The Society has had a successful year as is shown by the substantial increase in membership.

We began the year with a membership of 67; there have been 4 resignations, 16 elections and 2 members transferred from other centres, making a gain of 14 members—a total paid up membership of 81.

Three council meetings and 8 regular meetings were held, at which the attendance has been very satisfactory. The dates of the regular meetings, the lectures and titles of the addresses were as follows:

Jan. 25—J. A. Pearce, M.A.—Some Unsolved Problems of the Solar System.
Feb. 22—H. H. Plaskett, B.A.—The Nebulae.
Mar. 25—Rev. J. C. Goodfellow, M.A.—Sir Isaac Newton, His Life and Work.
Apr. 5—Dr. J. S. Plaskett, F.R.S.—Our Galaxy and Beyond.

May 12—Observation meeting at Dominion Astrophysical Observatory, Saanich.
Oct. 10—Chief William Shelton, Snohomish Tribe—Indian Folk Lore.
Nov. 10—W. E. Harper, M.A., F.R.S.C.—Exploring Space.
Dec. 6—Annual General Meeting—Astronomical Motion Pictures.

Rev. Mr. Goodfellow's address commemorated the 200th anniversary of the death of Sir Isaac Newton.

Owing to the fact that 34 members, 42 per cent., are resident outside of the city, the council this year decided to follow the policy of the Parent Society and, conforming to article VI of the Constitution, an official ballot for the 1928 officers was sent to every member in good standing. The following officers were elected for 1928:

Honorary President, Daniel Buchanan, M.A., Ph.D.; *President*, J. A. Pearce, M.A.; *First Vice-President*, H. H. Plaskett, B.A.; *Second Vice-President*, R. G. Miller, Esq.; *Secretary-Treasurer*, C. S. Beals, M.A., Ph.D.; *Council*, J. P. Hibben, Esq.; Rev. J. Goodfellow, M.A.; A. W. Giles; P. S. Langton, Esq.; G. A. Bucklin, Esq.; and the *Past Presidents*, J. S. Plaskett, D.Sc., F.R.S.; F. N. Denison; W. S. Drewry, C.E.; J. E. Umbach, C.E.; W. E. Harper, M.A.; James Duff, M.A.; and P. H. Elliott, M.Sc.

R. G. MILLER,
Sec.-Treas.

GENERAL TREASURER'S FINANCIAL STATEMENT FOR YEAR ENDING DECEMBER 31, 1927

GENERAL ACCOUNT

RECEIPTS, 1927

Cash in Bank, December 31, 1926	$ 633.72
Grant from Dominion Government	2,000.00
Grant from City of Toronto	100.00
University of Toronto (50 Journals)	100.00
Fees of Members	961.45
Bank Interest	61.05
	$3,856.22

DISBURSEMENTS, 1927

Publications JOURNAL and HANDBOOK	$1,660.17	
Less received for reprints	54.25	$1,605.92
Public Meetings		126.72

Library Books		22.50
Salary Assistant Librarian		540.00
Stationery, Stamps, etc		279.17
Rent of Room		130.00
Fire Insurance		34.00
Grants—Ottawa Centre	$65.50	
Winnipeg Centre	49.00	
Montreal Centre	50.00	
Victoria Centre	64.50	
London Centre	43.50	
London Centre	43.50	272.50
Miscellaneous Expenses		25.00
Balance in Imperial Bank		830.41
		$3,856.22

Building Account

RECEIPTS

Balance, December 31, 1926	$671.00
Interest, Bonds $142.04—Bank $9.78	151.82
	$822.82

DISBURSEMENTS

Canadian Permanent Bond purchased	$500.00
Bank Balance a/c Ron. 293	322.82
	$822.82

Life Membership Account

RECEIPTS

Balance, December 31, 1926	$ 51.12
Interest, Bond $3.95; Bank .51	4.46
Three Memberships	75.00
	$130.58

DISBURSEMENTS

Canadian Permanent Bond	$100.00
Bank Balance a/c Ron. 322	30.58
	$130.58

BONDS HELD BY IMPERIAL BANK

Can. Permanent $500.00, $500.00, $500.00, $500.00 (Building a/c)	$2,000.00
Can Permanent $100.00 (Life Membership a/c)	100.00
Dominion of Canada $18,682, 5½% (Building a/c)	1,000.00
	$3,100.00

Audited and found correct
January 13, 1928
(Signed) JNO. B. FRASER
A. R. HASSARD.

H. W. BARKER,
General Treasurer.

OTTAWA, TREASURER'S REPORT FOR 1927

RECEIPTS

Balance from 1926	$60.69	
Grant from General Treasurer	65.50	
Interest	1.74	
		$127.93

EXPENDITURES

Advertising	$13.20	
Printing	33.30	
Lectures	15.00	
Postage and Stationery	4.06	
Incidentals	4.75	
Special Evening at Observatory	36.00	
Total	106.31	
Balance on hand	21.62	
		$127.93

The collection of fees for the calendar year of 1926 amounted to $131.00. So far this year $100 has been collected.

The membership has increased from 62 to 66 members; there were four resignations and eight new members elected.

(Signed) J. F. FREDETTE,
Local Treasurer.

Examined and found correct,
(Signed) R. C. PURSER.
Ottawa, December 9th, 1927.

LONDON, TREASURER'S REPORT

RECEIPTS

Balance brought forward	$65.22	
39 Members' fees for 1927	78.00	
3 Members' fees for 1928	6.00	
Grant from General Treasurer	43.50	
Interest on Bank Deposits	2.28	
		$195.00

DIEBURSEMENTS

Forwarded fees to General Treasurer		$78.00	
Printing notices for meetings		14.80	
Postage, stationery and exchange		2.57	
Lantern slides		15.00	
Expenses May observation meeting		6.50	
Flowers		6.00	
Mr. Fetchell for assistance at Normal School		2.00	
Charts and transportation of telescope for November meeting		6.66	
Balance { Cash	$57.40		
Balance { Fees paid in advance	6.00		
		63.47	
			$195.00

E. T. WHITE,
Secretary-Treasurer.

Audited and found correct
Dec. 9th, 1927
(Signed) { THOS. COLERIDGE / W. G. COLGROVE } Auditors.

WINNIPEG, TREASURER'S REPORT

YEAR ENDING DEC. 13, 1927

The balance brought forward from last year			$165.27
Cash received during the year:			
From subscriptions		$100.00	
Bank interest		6.16	
Grant from Toronto		48.75	
			154.91
			$320.18
Disbursements during the year:			
Remitted to Toronto		$74.00	
Advertising		36.90	
Lantern		12.00	
Luncheon to Dr. McLean and D. R. P. Coates		17.00	
Expenses Dr. Plaskett's Lecture		6.95	
Printing		6.24	
Postage and exchange		7.72	
Expenses Social Evening, October 26th		1.50	
			162.31
Balance forward to 1927-28			157.87

DAVID SAUNDERS,
Hon. Treasurer.

Audited
(Signed) A. W. MEGGETT
A. REED

Analysis of subscriptions:

Arrears collected	$10.00
Current Year	74.00
Paid in advance	16.00
	$100.00

VICTORIA, TREASURER'S REPORT

REVENUE

Bank balance, 1926	$94.86
Grant from General Treasurer	64.50
Bank interest	4.95
Subscriptions to Dec. 5, 1927	137.80
	$302.11

EXPENDITURES

Daily Times advertising	$27.84
Colonist advertising	32.17
" printing	9.10
Janitor's expenses	16.50
Lantern slides	4.20
Expenses lecture, Oct. 10th	15.00
Expenses—open air meeting, 1926	45.00
Stamps	5.25
Account and receipt book	3.45
Overdeposit, as per 1926 statement	2.00
Remittance to Toronto (subscriptions to Jan. 1st, 1927)	98.00
	258.51
Bank balance	43.60
	$302.11

R. G. MILLER,
Treasurer.

Audited and found correct.
H. H. PLASKETT, *Auditor.*

LIBRARIAN'S REPORT, 1927

Periodicals and publications of observatories and societies received during 1927 were as follows:

From Canada and the Empire	203
From the United States	170
From other countries	178
	551

As an exchange the JOURNAL was sent to addresses in:

Canada and the Empire	44
The United States	51
Other countries	52
	147

Among the books (other than periodicals) added to the Library were:

"History of Mathematics," by W. W. Rouse Ball, 1924.
"Astronomy," a revision of Young's "Manual," by Russell, Dugan and Stewart, 1926-27.
"Astronomy," by J. C. Duncan, 1926.
"Modern Astronomy," by H. Macpherson, 1926.
"Isaac Newton, 1642-1727," Essays ed. Greenstreet, 1927.
"The Sky Movies" for children, by Gaylord Johnson, 1925.
"The Book of the Stars" for young people, by G. E. Mitton, 1925.
"The Heavens and their Story," by A. S. D. Maunder and W. Maunder.
"The World of Sound" and "Concerning the Nature of Things," 1925, by W. H. Bragg.

The number of books loaned to members was comparatively small. While the accommodation for readers is very inadequate, there is a good collection of books on astronomy which the members may borrow.

C. A. CHANT,
Librarian.

CURATOR'S REPORT

There have been very few requests for apparatus or lantern slides in the past year. The Cooke telescope, which was out, has been returned and needs some overhauling. The Larratt Smith telescope is being used by one of the members. There have been but three or four requests for slides. The Shackleton Expedition set has just been returned, and there is at the present moment a request for a selection of slides for a popular talk on astronomy at Paris, Ont.

ROBT. S. DUNCAN,
Curator.

WIRELESS TIME SIGNALS AND THEIR APPLICATIONS

By J. P. Henderson

Meridian circle star observations for obtaining true sidereal time are made on practically every clear night at various observatories, including the Dominion Observatory at Ottawa, the Naval Observatory at Washington, and others. From these is found the correction that must be applied to the standard sidereal clocks, which are maintained under the most favourable conditions possible of constant temperature and pressure, usually in a room electrically heated and with temperature regulated by a sensitive thermostat with an electric fan to keep the air in circulation. Immediately before a wireless time signal is to be transmitted the mean time clock, or other clock that is to actually transmit the signal, is set correct, using the most probable value of the sidereal clock's errors obtained by extrapolating their rates from the last star observations.

For transmitting time a good clock is to be preferred for actually originating the signals, as it can be rated closely from day to day and only minor advancing or retarding done immediately before the signals are to be sent. Other methods have been used, such as an electrical automatic transmitting device which is started by a given impulse from the standard clock and is expected to maintain a sufficiently uniform rate for the duration of the transmission or else is synchronized electrically with the clock. This is used at the German and French observatories transmitting through POZ (Nauen), and LY (Croix d'Hins). Such is especially useful for sending complicated programmes of signals, such as the ONOGO, where a different letter or group of dots and dashes is sent each minute, generally necessitating sending-discs which would be difficult to connect directly with an ordinary time clock. Hand transmission by an operator who watches the clock is nearly entirely a thing of history.

While the mere voice announcement of the time may be sufficient for most broadcast listeners there are many who wish to

check accurately their watches or chronometers from day to day, for which purpose seconds' beats are very desirable. A recent radio development is the sounding of a musical gong or chimes on a particular designated second. The U.S. wireless stations for years have transmitted an electrical impulse actuated from either the pendulum or escapement of their standard mean time clocks, the beats being every second for 5 minutes but having omissions on the 29th, the 55th, 56th, 57th, 58th, and 59th of each minute, except in the last minute when the 50th to the 59th are omitted and a dash is sent on the hour. The beginning of each beat and of the dash is assumed to be at the beginning of the second. This system is very satisfactory for many general purposes and for the coincidence method of comparison which will be discussed later, but it has the fault of not carrying anything distinctive to the various minutes excepting the last, so that a listener must hear the first or the last to be able to make a positive comparison. The European systems avoid this in several ways, the ONOGO for example having x's sent for the first minute, n's next minute and g's the final minute, with the short dot in each case being precisely on the 10th, 20th, 30th, 40th, and 50th seconds, and with 3 dashes during the last 5 seconds of each of the minutes, the end of the last dash being exactly on the hour. A later edition of this is now what LY and FL send, namely a series of 6 dots on each of the last seconds of the minute, the 55th, 56th, 57th, 58th, 59th, and 60th seconds, the last dot of all being on the hour. This system combines most of the advantages of the others in that each of the three minutes is an integral itself and sufficient for a complete comparison.

For accurate and convenient comparisons a vernier system is best—a series of dots starting say at 1 minute after the hour with defining dashes (or omissions), and rated differently from the clock that is to be compared, so that coincidences may be observed. For Nauen, Germany, the defining seconds, which are lengthened into dashes, are now the 1st, 61st, 121st, 181st, 241st, and 301st and their transmitting clock has a gaining rate which makes the transmitted seconds .9797 the length of sidereal seconds. The rhythmic signals sent out by Bordeaux, France, are those recommended by the International Time Commission of 1925 and agreed upon at the

Cambridge meeting of the Astronomical Union. It comprises a series of 306 signals emitted in 300 seconds of mean time. The 1st, 62nd, 123rd, 184th, 245th, and 306th seconds are single dashes of .4 seconds duration and commence exactly at the minute. The dots are .1 second duration and the space between the beginning of any two consecutive signals is 60/61 of a mean second. This is also the type of signal to be sent out by Rugby on a wave length of 18,740 metres.

Methods of Comparison.

Where eye and ear methods are used, personal equations are sure to be of serious dimensions for accurate determinations and great precautions must be taken. The time as observed using the last dot of the "n" or "g" in the European systems will, with most observers, be found to give different results from that obtained by using the dashes or plain dots, which will again be different from that obtained by the vernier system. If a key is operated by hand and recorded on a chronograph, the personal equation may be eliminated by having the recording local clock also beat in similar musical pitch and intensity in the 'phones and recording it similarly by hand. The chronograph record can then be measured with reference to the original clock beat record and the personal equation thus indicated always allowed for in the calculations unless it had been automatically done in the recording and scaling. There remain the irregularity and possible change in personal equation value resulting from different strengths of signals if not carefully set each time.

The coincidence method where both the local clock ticks and outside signal are heard in the 'phones and the moment selected at which they appear to coincide is liable to bring a personal equation with considerable differences between observers, though for a given person it is quite regular under similar conditions of reception.

The coincidence method (see this JOURNAL, March, 1925) seems to give very satisfactory and uniform results and has very small and generally negligible personal equations with different observers. This has been used for years at the Dominion Observatory and has been carefully investigated to determine possible sources of error. In this method the local clock is either faster or

slower than the incoming signals and its breaks are longer than the signals—if necessary they can be lengthened by the adjustment of the chronometer contacts, relay tension or magnetic field, extra relay or magnetic inductance in series which allows the current in the relay magnets to build up gradually and takes sufficient time before complete restoration—the local clock or chronometer opens the wireless circuit so that no signal is heard during the first part of each second as read on its face—the actual time of disappearance or of reappearance of the incoming signal is observed; then by keeping record of the local clock reading at the moments of the de-

Fig. 1. Smoked paper record of NSS and sidereal clock; also coincidences with differentially rated chronometer.

fining seconds' beats which are received on the wireless receiver, the time by the outside which corresponds to the moment of coincidence is found.

Observations on both the disappearances and appearances (by reversing the contact systems or making them work oppositely by having them short an output in place of connecting it through) were made and compared to actual chronographic records made of these, using a needle pen recorder scratching on smoked paper. This pen also of course recorded the signals as well as our local clock with which the comparison was being made, giving another independent comparison. (See figure 1).

Signals may be recorded with a siphon recorder on either tape or chronograph drum along with the clock with which it is desired to compare them. To prevent variations due to different strengths of signals the clock should produce a signal similar to the incoming one in both pitch and strength—say by a local tube oscillator with volume control.* The output should be introduced at a suitable

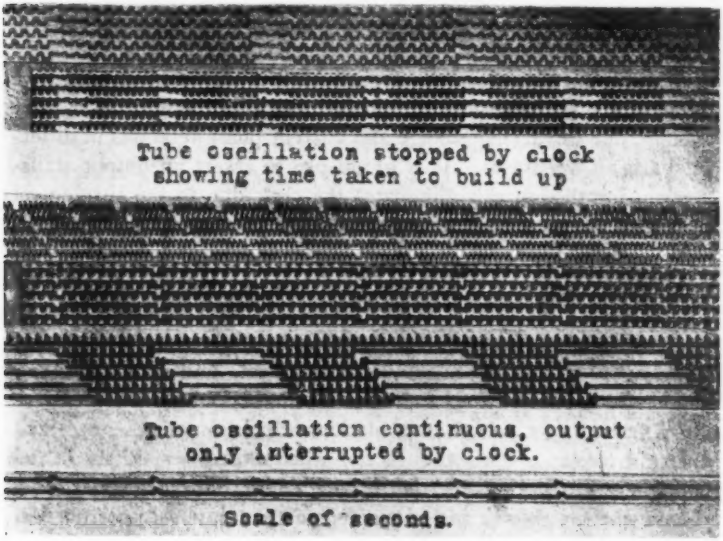

Tube oscillation stopped by clock
showing time taken to build up
Tube oscillation continuous, output
only interrupted by clock.
Scale of seconds.

Fig. 2. Low frequency tube oscillator recording through syphon recorder.
Fig. 4. Part of LY time transmission, showing international and vernier systems.

point in the audio amplifying system of the receiving and recording set. Such a tube oscillator should oscillate continuously and have its output only shorted by the clock relay, in order to prevent delay necessary in building up the audio oscillation from zero to full value each time. Illustrations showing records of actual tests indicate

*An audio oscillator tube set has been in use to obtain steady pitch for transmission of time signals from CNRO, Ottawa, and CNRA, Moncton; it is much preferable to any buzzer, since it gives a good sine curve of EMF and is of constant pitch if the tube filament is always set at the same brilliancy.

clearly the time taken by the tube with transformer and condenser system (tuned to a frequency of around 10 cycles per second) to build up to approximately full, this being of the order of from one to four cycles, where no definite starter impulse is applied. (See figure 2).

A method of completely extinguishing a signal which was developed at Ottawa may be of interest. It is well known that, when a relay in series with the ear 'phones opens, it does not completely cut out all sound, for the 'phones being very sensitive react to the very small currents passing through certain unavoidable capacities in circuits. To balance these out by neutrals or otherwise is very difficult, due to varying voltage and current phase relations in different parts of apparatus. It is of no use to insert an output transformer, for though this eliminates the click due to the turning on and off of the d.c. plate current it does not prevent a residual signal from coming through by capacity. In three-coil receivers with more than one tuned circuit the relay may be put in the aerial or ground leads (this cannot be done in two-coil regenerative receivers because in these a distinct click is caused by the opening and closing of the aerial circuit due to the detuning effect) and where coupling is loose fairly satisfactory results are obtained, though it is occasionally difficult to get rid of other stations which sometimes are heard when the circuit is open, though not when closed—especially in the field where sets have to be used in wet tents. Also it was desirable to have the set receive the outside signals continuously so that the signals could be recorded on the chronograph without interruption and yet use some of the output for the ear coincidences with the differentially rated chronometer. It is not convenient to operate two well-tuned sets on adjacent aerials with self or even with separate local heterodynes, especially if a relay is opening and closing one of the aerials. A successful solution was to step down a part of the output of the receiver by a transformer of say 10 to 1 ratio so that the voltage that could carry through capacity effects would be small, put the clock relay in series, and then step the voltage back up again to a suitable value for the ear 'phones by a similar transformer reversed. The clock relay contacts then operate in a circuit through which no direct current flows, hence no click is heard in the

'phones when the points open or close, and since the alternating voltage is low across the points of the relay there is no trouble with capacity feeding the signal through while the points are open. If it is wished to reverse the action of the clock relay its contacts may be placed in parallel to the middle transformer windings in place of in series, and then no signal will be heard when the points are closed, just the opposite of the previous case, for when in series, signals will be heard when the points are closed. This method has been eminently satisfactory in the last two years and has entirely displaced all the other methods of cutting out for coincidences both in the field and at the Observatory, where recording is done with the remainder of the output of the receiver, which is unaffected by the coincidence chronometer relay; it having been tapped off before reaching this pair of audio transformers. For field use it is highly desirable, as no difficulty is experienced through dampness, leakage, etc., since these currents are of audio and not radio frequencies.

A few of the stations transmitting reliable high power time signals are:—

1. *United States.* NSS, Annapolis, Washington. 17,145 m. (also NAA on 2650 m. and on a short wave) noon and 10.00 p.m. E.S.T., seconds' beats for 5 minutes before the hour with the 29th, 55th, 56th, 57th, 58th, and 59th omitted of each minute and in addition the 50th on till a dash on the hour during the last minute.

2. *France.* LY, Croix d'Hins, Lafayette, Bordeaux, 18,900 m., 3 a.m. and 3 p.m. E.S.T. First the new international system before the hour, then the vernier system, 61 beats to the minute for 5 minutes, starting 1 minute after the hour and having dashes starting on each minute exactly.

3. *Germany.* POZ, Nauen. (AGW) 18,000 m. 7 a.m. and 7 p.m. E.S.T. First the ONOGO system till the hour, then starting about 1 min. after the hour a vernier system with dashes on the 1st, 61st, 121st, 181st, 241st, and 301st, gaining about 1 sec. in 50 sec. and series ending about 5 min. 53 sec. after the hour.

4. *England.* GBR, Rugby 18,740 min. 5 a.m. and 1 p.m. E.S.T. Rythmic series similar to that of LY.

There are a number of other stations also transmitting but the above have always been used as they are very reliable and correc-

tions are available for them from astronomical sources, besides tying in time systems of the main countries in the world.

Types of Receiving Sets.

A two honeycomb coil regenerative receiver with one condenser and one regeneration (moving coil) control is still much used where comparison is made merely by observing a watch. Usually a couple of audio stages are used. Such a set has been made and used of vest pocket size, tuning to 19,000 m. It is very useful where every ounce of weight is serious on long overland portages between canoe streams. Amplification is added merely to overcome local noises such as rapids in streams, winds, birds singing, dogs barking, or mosquitoes preparing for lunch. It can be used with very small aerials such as on small skiffs, canoes, or merely stuck up on stakes a foot or so off the ground. A knife with wire wound around it stuck in the turf is sufficient for ground, though a dish of water may be poured down beside it to dampen the ground.

The three-coil set with two sharply tuned circuits is preferable for all coincidence comparisons, due to the many powerful stations now operating close together in wave-length. A couple of stages of audio amplification are usually added.

The receiving equipment in use at the Dominion Observatory consists of a radio frequency amplifier completely tuned, with plate regeneration controlled by a resistance in series with the tuning condenser, detector with grid circuit tuned, coupled with which is the output of a heterodyne oscillator which is calibrated for wave-length. One stage of audio amplification gives satisfactory signal strength for coincidences, output being divided between the transformer for the coincidence obliteration of signals by the chronometer and the input tuned transformer of a three stage selective audio amplifier. This latter unit is set to amplify strongly only between C sharp and E or about 1-1/2 tones on the musical scale, other signals, etc., going through poorly and without amplification. The output of this is fed to another tube, which in turn feeds a power amplifier tube operated direct from the a.c. through a transformer for convenience, but having a dynamo (500 v.) plate supply, grid

biased rather strongly to cut down plate current when no signal is present. Any ordinary telegraph relay might be placed in this output circuit, but instead a step-down transformer is used, whose secondary current, rectified by a tungar tube (separately lighted by a transformer), with slight battery assistance on account of the characteristics of the tungar, and a high resistance (say 1000 ohms) forming non-inductive circuit to maintain the ionization in the tungar tube, passes directly to the 10-ohm magnets of the chronograph, and records with pen on paper without any relay whatever in

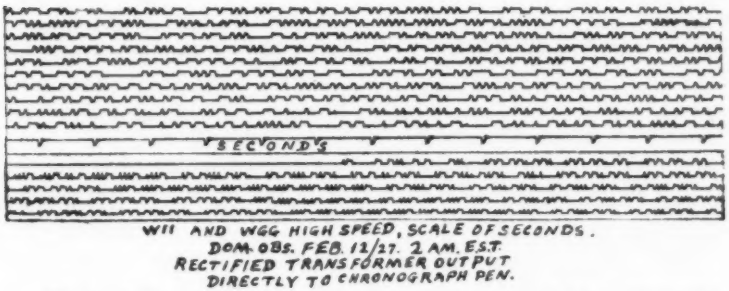

SECONDS
WII AND WGG HIGH SPEED, SCALE OF SECONDS.
DOM. OBS. FEB. 11/27. 2 AM. E.S.T.
RECTIFIED TRANSFORMER OUTPUT
DIRECTLY TO CHRONOGRAPH PEN.

Fig. 3. Section of drum record of telegraph transmission made without interposition of any relay.

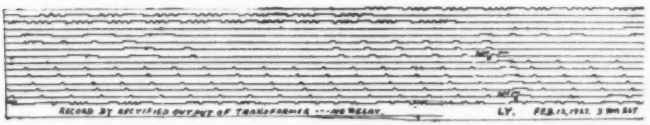


Fig. 4. Part of LY time transmission, showing international and vernier systems.

circuit. The transformer secondary in this case gives over a watt of a.c. power, when the heterodyne is set to give the proper frequency for the selective audio amplifier, when LY, France, presses his key. This of course is quite sufficient to light a small electric bulb brilliantly, and the time signals may be watched coming in or the stations read by eye. Clock signals are introduced by means of an audio oscillator as described above, and go through the last amplifier stages along with the wireless signals.

A more portable equipment can be designed in order to be

suitable for field use, but this requires the employment of a sensitive relay whose resistance is suitable for operating directly from the plate circuit of a small receiving tube. A tube in the audio amplification series handling fairly strong signals has its grid biased so that there is no appreciable plate current when there is no signal. A resistance of say 50,000 ohms carries its plate current when there is a signal. The next tube is fed by condenser coupling, having a grid leak to filament to hold its grid at nearly zero bias. Normal plate current flows in this tube when there is no signal and the magnets of the relay carrying this current will hold their armature closed. When a signal is imposed the previous tube becomes of low impedance, its B battery then imposes strong negative bias on the grid of the final tube, stopping its plate current and releasing the armature of the relay, which then records through the chronograph. The total lag through one such equipment was found to be about 0*s*.007, which included all incidentals such as audio frequency building up in amplifiers, relay itself, etc.; probably the majority of this was in the adjustment of the relay itself, for although recording on the "open" this lag time could be lengthened if the magnetic field had not enough air gap, the armature being too close to the magnets.

Some Experiences.

A few incidents of actual experience might not be out of place here, to show the difference in field work and in the laboratory. Years ago we started out with a set built to accepted ideals with grid leak and all. One day was warm and sunny, the next wet and cold, and we soon found that no tube would adjust itself or its grid bias under such conditions without solid metallic connection, which we made on the spot and have used ever since. We have not since that time put out a set for either long or short waves for use in the field having a grid leak and condenser, and, without boasting of our success or any special novelty, I think I can say that in practically every case we have had sets that would give signals comparing favourably with the best and yet would stay usable under all reasonable conditions, often when a condenser and leak biased set could not operate at all. If anyone disputes this possibility from a theoretical standpoint I am prepared to grant the conventional con-

struction should give better detection, but I would point to many unreliable grid leaks as well as condensers I have tested, ask him to watch a pack horse carrying a beautifully made set across some mire and over some creek until he stumbles at some place, and it becomes necessary to pour the water out of the inside of the wireless set that night—and dry it out in a hurry beside the fire and get NSS in a wet tent and sitting on the ground—such is the field life; and then the mosquitoes come along and sing as loudly and sweetly as any heterodyne could on NSS. One of the sets we sent out to the North West Territory had three good soakings and as many drying outs on the way in the first season, and was in operation each time immediately the coils were dried out—it has been working now about four summers, with alterations made only to adapt it lately for tubes more economical with batteries.

Some years ago we put out the first of a type of combination set for operation on two specified wave bands, a double-throw double-pole switch changing from one band to the other. Separate regenerative coils are used, but the same tubes and two variable condensers, one in series with the aerial and the other in parallel with the tuned coil. Most of these sets have been made to cover bands 200-750, and 7,000-20,000 m. the shorter waves being used for concerts and also ships and weather, and the longer for time signals and long wave press reports. Any two bands could have been selected and built into the set. They were not made with plug-in coils for changing because of the difficulty we have always experienced in assuring that the contacts will remain good when used in outside work; also a lot of separate coils are troublesome to carry.

An ammeter for measuring the current in oxide-coated filaments gives regularity of calibration for wave-length, as well as indication of bad connection or weak battery, as all the filaments are in series and the bias for detector and amplifier is thus uniform and remains set at any prearranged value. When size and weight or cost advise against the meter, a tungsten flashlight bulb of the same amperage as the tubes (again all in series) is used, the rheostat being set while watching the flashlight. It is a great convenience and satisfaction and a saving of tubes for such a set to

have the temperature coefficient of resistance of such a tungsten at white heat set against that of the platinum or dull glowing filaments or the oxide-filaments.

While operating one of these sets with a flash bulb in the panel a flicker in the lamp indicates a bad connection in the filament of any

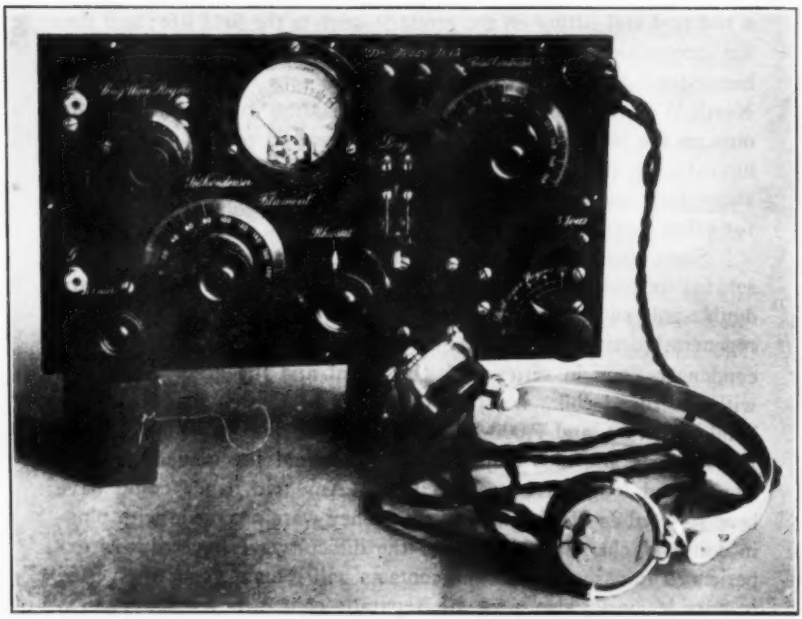


Fig. 5. Small portable field receiver for two wave-bands.

tube or elsewhere in the A battery circuit. We have not managed to overcome the base contact trouble by any method permanently except by soldering in all the tube leads to the wiring of the set and scraping the sockets. Socket trouble does not start immediately when the equipment is new, and later, when it does, the points have become oxidized by exposure to weather, it is most elusive and difficult to remedy, as sockets, etc., cannot be conveniently cleaned in general. The same applies to condensers which depend on fric-

tion for electrical contact, they are all right only when new. We have been forced to "pigtail" everything possible, including rheostats and switch arms where selector switches are used.

We much prefer to use the simplest of circuits, but we try to get them to be the most efficient possible. The wave-length range

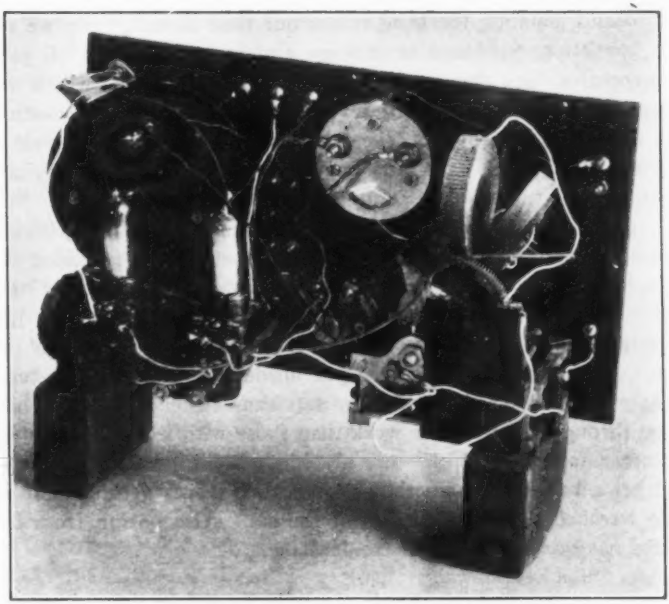


Fig. 6. Small portable field receiver for two wave-bands.

covered by any ordinary coil and condenser alone may be as high as 1:10, but we usually think we are doing well if we make sure of 1:6. The condenser is of (say) 500 mmfd. capacity. We add a tube whose grid to filament capacity is (say) 5 mmfd. to the minimum of that condenser, which is (say) 25 mmfd. and put the whole in the set and what wave-length range do we get? By experience with very many examples we do well if we get a range of better than 1:2 and the difficulty must be in the capacity in the additional

wiring, as we incorporate that unit in the set. However, our aim is at least 1:3, and sometimes we get as high as 1:5 wave-length range by careful design of dry wound coils and placing of wiring with consequent improvement in efficiency, selectivity and range. To gain selectivity, which is most necessary on account of the great multitude of long-wave stations operating in different parts of the world and jamming the band where our time signals come, we test for insulation resistance or leakage and make sure that all parts incorporated into the set have the highest insulation, which will remain so during all sorts of service. When such due precautions are taken the resulting set, even though comprising the simplest of circuits, has never failed to have the maximum selectivity and sharpness of tuning.

After some years, in which we generally placed the necessary operating batteries inside the box with the set, we have decided that this does not pay. It makes the set heavier and consequently more liable to harder handling, more bulky, and more subject to injury through dampness, though of course it is much quicker to place into use. Also if batteries must be put inside they should be fastened only with good elastic bands, for sets thus fastened together have gone through much harder work than those with wood, brass, strips or other fasteners which were absolutely solid, so that when they did get a bad knock something broke, then pieces getting loose inside wrecked the delicate parts of the set. Also oozing from batteries has occasionally been troublesome.

Multiple Feeds through Amplifiers.

Besides introducing the local oscillator, which is turned on and off by the seconds' relay of the standard clock, at some point in the amplifying system, more than one detector or detector and amplifier unit, each adjusted to give about the same volume from outside signals, and receiving any specified wave-lengths, may be connected together and their outputs superimposed upon a further amplifier whose output then goes to the 'phones, or other instruments. This provides a standby using one pair of ear 'phones or recording on as many waves as desired, and for which aerials and receivers are available. This is applicable still more widely, the only precautions

necessary being to use separate batteries or else to see that no mix-up of currents occurs through interconnection, transformer or condenser feeding being resorted to if necessary for insulation purposes with but slight loss. Each set may have a different number of tubes merely to give about equal input to the common stage beyond. It may be done at radio frequency equally as well as at audio. By reversing direction of feed from the detectors (either *rf* or *af*) and using two sets and two aerials, one directive and tuned to a desired station, and the other oppositely directive and tuned to the interfering station or static, much better reception can be obtained than by a single set and tuning alone. Here the undesired signals or static are made to neutralize themselves as they enter the common stage from the two sets, and leave only the desired signal which is coming in alone through one of them. Difficulties and limitations appear to be only those of securing exact opposite phase relations simultaneously in both EMF and current in all parts of the opposing fields.

A method for cutting down feed to amplifiers and for preventing parasitic oscillations by allowing some losses, is to use one tube (or two tubes push-pull) as pure resistance load across a transformer winding; the impedance of the plate-filament circuit is then variable by changing the filament brightness.

Special Uses of Time Signals.

Our magnetic survey staff use a couple of sets in all parts of Canada for obtaining the rates of their chronometers, with which they determine accurately the time of swing of their magnetometers, for finding the strength of the earth's magnetic field. Our gravity survey staff use wireless coincidence comparisons for determining accurately the time of swing of a free pendulum, swinging in partial vaccum, from which the gravity, or pull of the earth, at any point is found; variations in gravity from place to place give a glimpse of the character of the earth's crust beneath and near the station. Quite a number of sets are used to obtain accurate time to record on seismograph sheets, from a collaboration of a number of which in different parts of the world the location of earthquakes is found. In this work weak points and shift planes in the crust of the earth

are located—very important for the building engineer who is warned what type of building should be constructed, for the mining and construction engineer to beware of locating mine tunnels or insufficiently reinforced water conduits crossing these weak places, and for the ocean cable laying engineer who should avoid laying his cable across shift planes in the ocean floor.

Finally longitude requires accurate time comparisons, for in reality it is the star observations at the main observatories which are being connected to the star observations at the field station. To do this there is a standard clock at each end, or perhaps only a chronometer at the field station, and the time signal transmission and reception should take place as close to the time of star observations as possible. Accuracy in location of principal points is needed for mapping districts, water courses and navigable lakes and oceans, for on the reliability of these many things depend, such as international and other boundaries, location of mineral claims and mapping of navigation channels. These uses are in addition to the necessity of accurate time for ships on the ocean for locating their geographical positions from time to time and their location relative to land.

Many other purposes are served by wireless time signals, such as timing eclipses accurately between locations, rating clocks and chronometer, regulation of frequency of a.c. electric supply, timing and interrelating static and aurora impulses received at different stations, etc.

Short Waves.

So far we have been dealing particularly with the long waves, but the short demand attention. Amateur radio operators have repeatedly demonstrated the possibility of communicating over long distances on short wave with such ridiculously low power as was never thought of ten years ago. There is no doubt of the wonderful future ahead for the short waves, but we must remember their limitations. Just as X-rays penetrate where light rays will not—yet light waves travel when X-rays have long since been lost—so we have anomalies in the radio bands which are being constantly investigated and solutions offered. Suffice it to say that a short-wave time transmission both from NPM and NKF in the middle of

the day was not received, though expected, during the international longitude determinations, for which we sent a party to observe in Vancouver during October and November, 1926, but the short-wave transmissions at all the other hours came through with wonderful signal strength and freedom from static. Work is being done on them, discovering freaks of various sorts, investigating the skipped distance phenomena, polarization, etc., but until all these matters are cleared up our reliable time service must be maintained in the long wave band, even though requiring hundreds of kilowatts, though transmission on several waves simultaneously is still more desirable.

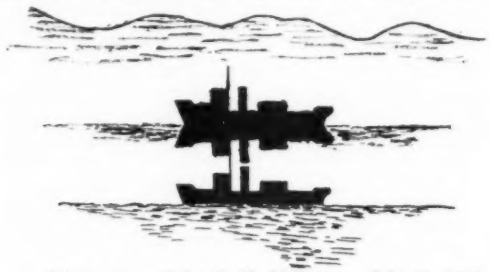
Dominion Observatory,
January, 1928.

TWO OPTICAL PHENOMENA OBSERVED

1. A Mirage Seen Near Victoria, B.C.

Note by P. M. Millman

This peculiar mirage was seen on July 31st, 1927, at 4.15 in the afternoon. It appeared in the Straits of Juan de Fuca, off Victoria, B.C. The day was hot and clear with a temperature of about 65°. As will be noticed from the illustration two images of the ship appeared above the ship itself. The inverted image is not a mirage of the reflection of the ship since the surface of the straits was broken by small waves and no reflection of the ship was visible. The distance was estimated as between 5 and 8 miles and I observed it from the top of small cliffs about 100 ft. high. The distant shore line and the Olympic Range, about 20 miles away, were also elevated. For some time the mirage was just as clear as the ship itself and then, as we drove along the shore, it was crossed by wavy lines and gradually disappeared.



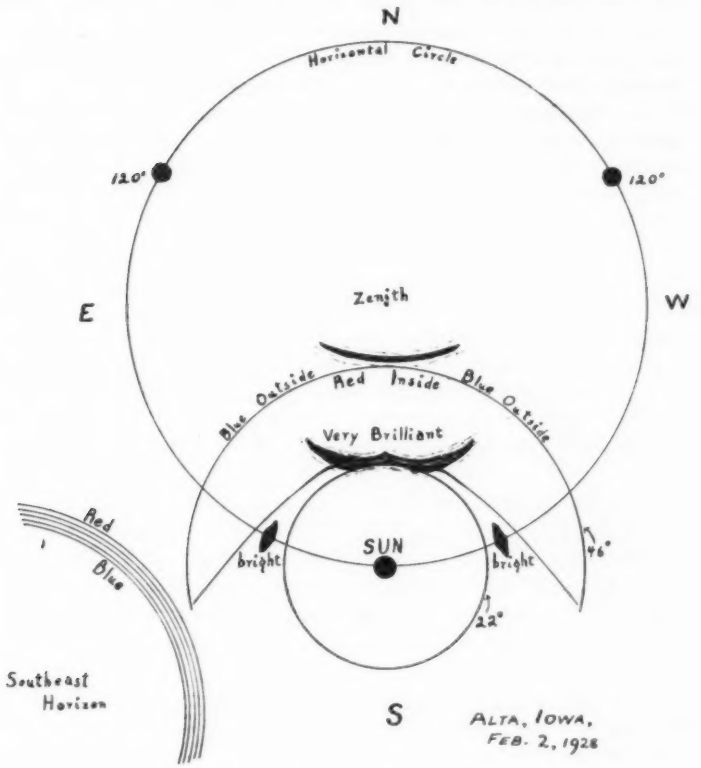
Mirage observed by P. M. Millman on July 31, 1927.

2. An Interesting Halo

Note by A. F. Hunter

David E. Hadden of the Astronomical Observatory, Alta, Iowa, sends a diagram and description of an interesting solar halo observed by him on Feb. 2 from about 10.45 a.m. to 12.30 Central Standard Time. "The day was warm," Mr. Hadden states, "for

the time of year, temperature 45°, sky clear except for the thin cirro-stratus cloud which was responsible for the halo. It was during the passage of this cloud in the forenoon that the phenomenon was brightest; and the infra-lateral arc, which was very brilliant



Halo observed by David E. Hadden on February 2, 1928, at Alta, Iowa.

occurred about 11.45 am., in the southeast. None was seen in the southwest direction on account of thicker stratum of cloud. This arc was as bright as an ordinary rainbow." The parhelic circle (white) was present, passing through the sun and running around

the sky. The spots of greater illumination at 120°, on this circle, are sometimes explained as "dogs" of the anthelion, or the bright spot immediately opposite to the sun; but their positions and the absence of the anthelion itself would seem to indicate that some other explanation of their presence is required. The ellipse, which circumscribes the primary circle at 22° from the sun, appears to have been present, at least its upper half. The occurrence of this circumscribing ellipse is a very rare phenomenon, quite as rare as the infra-lateral arc, at the lower left corner, with which it seems to be somehow connected.

WHAT MEMBERSHIP IN THE ASTRONOMICAL SOCIETY MEANS

By H. W. Barker, *General Treasurer*

The wonders of the heavens make a strong appeal to the enquiring mind. The awakening of one's consciousness to some of the great facts concerning the material universe, which may come through reading a book or listening to a lecture, is but the beginning—a mere introduction to this fascinating intellectual recreation. No lover of nature will be satisfied unless his knowledge grows from more to more. The interest which has been aroused needs to be sustained. The real enthusiast will want to learn all he can about the heavenly bodies. He will want to make friends of the planets and stars and find out where to find them in the evening sky at different seasons of the year. Take Orion, for example. Just as we long to see a companion who has been away from us for a few months, so we look expectantly as winter approaches for the return to the evening sky of "the great giant Algebar—Orion, hunter of the beast." His coming is like the home-coming of a friend.

The annual membership fee of $2.00 in the R.A.S.C. covers a year's subscription to The Journal, brings the member a copy of "The Handbook," gives the privilege of obtaining books from the large library in Toronto, and also, through the meetings at the various Centres, keeps the member in touch with things astronomical through instructive lectures and helpful discussions. Either of the publications alone is worth more than the annual fee. Lest the amateur should imagine that the articles in The Journal are too technical for him to understand, let it be said that the Editor always sees to it that each issue contains something at least—and usually a great deal—which one who has but an elementary knowledge of astronomy can understand and profit by.

"The Handbook" contains a fund of information for one's guidance all through the year—information concerning the phases of the moon, the position of the planets each month, the move-

ments of the satellites of Jupiter, variable stars, eclipses, and much more. It is indispensable for those who desire to follow the movements of the heavenly bodies.

New astronomical discoveries are constantly being made and additional facts of startling interest obtained. The ardent student of astronomy wants to keep his information up to date. This can be done only by current reading and thus learning of these discoveries and investigations as they occur.

For the above and other reasons membership in the R.A.S.C. means much to both the professional and the amateur, for THE JOURNAL keeps its readers informed as to the progress being made in astronomical research.

The retaining from year to year of those who are already enrolled on the books of the Society, and the adding of new members, should receive constant attention from all the officers. New members will always be welcomed into the fellowship. It is immaterial which Centre one joins. The location of the Centres and the names of the officers are given on the inside back cover. Upon acceptance, the name and address of the new member will be advised to the general office, and upon receipt of same the publications will be forwarded.

With a little additional effort on the part of the officers and the present members at each Centre our membership roll can be materially increased, and in this way the privileges of the Society will be extended to a larger group.

THE PLANET MERCURY

A Concise Tabulation of Many Items of Interest to the Amateur.

By W. G. Colgrove

Name.—Since the ancients never observed this planet except in the morning or the evening sky they thought there were two of them and therefore, as in the case of Venus, gave it two names. The Egyptians called it Horus and Set—the gods of good and light, and of evil and darkness. The Greeks named it Hermes, the sparkling one; while the Romans gave them the names of two brothers: Apollo, god of the day and the light, and Mercury, god of the dark, of thieves, of doctors and of merchants. Later, because of the planet's remarkable agility, the chemists adopted its name for the element quicksilver.

Myth.—In classical mythology Mercury was the son of Jupiter and Maia, most beautiful of the seven Pleiades. He presided over the winds, commerce, wrestling and everything that required dexterity and skill. Later be became the messenger of Jupiter and wore the winged cap and sandals which made his movements so swift, silent and successful. In art he has been often represented in statuary and in painting.

Symbol.—This is the Caduceus, a rod entwined with two serpents, which, when used as a wand, would produce sleep. This is also a symbol of modern chemistry and commerce.

Sound.—In the poetry and philosophy of the Music of the Spheres Mercury was assigned the part of high soprano. Even the great Kepler seemed to think that the high speed of the planet would cause a sound of high pitch.

Colour.—Mercury presents a brilliant golden aspect in the sunlit evening sky but in the morning it shines with a soft yellow hue.

Markings.—These are very difficult to observe on account of the great brilliancy of the planet. Lowell claimed to have seen some irregular marks which he called great cracks in the parched

surface which is probably always exposed to the intense heat of the sun, especially during the perihelion passage.

Stellar Magnitude.—From —1.2 to +1.1. That is from about the brightness of Sirius to that of Aldebaran.

Angular Diameter.—This varies according to its position in its orbit with reference to the earth, and the variation increases from 4.5″ at superior conjunction to 12.9″ at inferior conjunction. Its mean apparent diameter is about 9″. At greatest elongation it is about 7″. .

Linear Diameter.—Its mean actual diameter is about 3,000 miles, and its mean circumference about 10,000 miles. It is smaller than either of the two larger satellites of Jupiter.

Area of Surface.—About 28, 300, 000 square miles, or about 1/7 of the earth. The surface is probably very mountainous for in a large telescope one can notice the unevenness of the terminator.

Volume.—About 14, 137, 000, 000 cubic miles, or about 1/18 of the earth or 1/23, 800, 000 of the sun.

Mass.—Perhaps 1/18 of the earth. This is very difficult to determine on account of the absence of a satellite, but it has been estimated from the perturbation of certain comets like Encke's that occasionally pass by.

Surface Gravity.—About .31 of the earth. If you should go to Mercury your weight would be less than 1/3 what it is here.

Density.—About .85 of the mean density of the earth.

Rotation Period.—Probably 88 days, the same as its period of revolution, so that the same face of the planet is always turned toward the sun.

Distance from Sun.—28, 550, 000; 35, 950, 000; 43, 350, 000 miles. These are the perihelion, mean and aphelion distances, respectively, and indicate a large eccentricity of the orbit. Its mean distance is only about 1/80 of that of Neptune.

Distance from Earth.—This ranges from about 50, 000, 000 miles at the most favourable inferior conjunction to about 136, 000,-000 miles at the remotest superior conjunction. The average distance from the earth will, of course, be about equal to our distance from the sun.

Diameter of Orbit.—71, 900, 000 miles. This is double the

mean distance, and when multiplied by 3.1416 gives a circumference of about 225,900,000 miles.

Revolution (Sidereal Period).—88 of our days. This is calculated from the synodic period because it cannot be accurately observed. It is about a quarter of our year so that if we lived on Mercury we would be about four times our age expressed in Mercury's years.

Revolution (Synodic Period).—116 of our days. This is the length of time that elapses between two successive conjunctions and varies slightly on account of the way the orbits of Mercury and the earth are placed.

Orbital Velocity.—This varies greatly because of the large eccentricity, the mean being about 30 miles a second, 108,000 miles an hour, 2,500,000 miles a day. At perihelion it speeds up to 6° a day or 36 miles a second, while at aphelion it slows down to less than 3° a day or 23 miles a sec. Its mean daily motion is about 4° or 14,732″ as compared with Neptune at only 22″ per day.

Arc of Retrograde.—12°. This is the result of the combination of the planet's motion and ours and is only apparent. When changing its direction from direct to retrograde motion it seems to stand still for some hours. Inferior conjunctions of Mercury and Venus occur during this retrograde motion.

Eccentricity of Orbit.—.206. The sun is thus out of centre about 7,400,000 miles. This is about 12 times the earth's ratio and makes a total difference of 14,800,000 miles between aphelion and perihelion distances. This is the cause of the variation of maximum elongation from 16° to 28° and produces two slightly different seasons.

Libration in Longitude.—This depends on the amount of the eccentricity of the orbit and is caused by the faster and slower speed at perihelion and aphelion. The result is an apparent oscillation of rotation of the disc east and west. In the case of Mercury it is greatest of all, being about 23.5° each way, making 47°. Thus on about 3/8 of his surface the sun always shines; on about 3/8 there is constant darkness, and on about 1/4 there is alternate sunlight and shadow.

Solar Radiation.—Mercury receives, per unit area, an average

of about seven times as much as the earth. At perihelion it gets more than twice as much as at aphelion. This is, of course, due to the eccentricity. The angular diameter of the sun as seen from Mercury at perihelion is 104′ or 3¼ times the apparent diameter of the sun, as we see it, while at aphelion it is only 67′.

Temperature.—The heat on the permanently sunlit section of Mercury is from 10 to 4 times hotter than it is here, and some 6,000 times greater than on Neptune. The permanently dark section will be exceedingly frigid, and the portion where light and darkness alternate every 88 days has a gradual increase and decrease of temperature.

Atmosphere.—There is very little or no atmosphere for there is no faint ring of light around the disc during transits of the sun. No clouds have been discovered and it is altogether likely that the one-time atmosphere has long since been evaporated or absorbed.

Albedo.—.06. This means that only about 6 per cent. of the sunlight falling upon it is reflected.

Inclination of Equator to Orbit.—This is not yet known and may be zero. The seasons will be largely dependent upon varying intensity of sunlight and heat according to the orbital eccentricity and velocity.

Inclination of Orbit to Ecliptic.—7°. This is greatest of all.

Phases.—Mercury has phases similar to those of the moon and Venus. At greatest elongation east and west it appears as a half disc, as it approaches superior conjunction it becomes gibbous, as it approaches inferior conjunction it becomes crescent. At the former it is hidden in the sun's rays so that we cannot see it, while at the latter it is invisible because its dark side is toward us.

Longitude of Ascending Node.—46°. The descending node is opposite and these are the points on the ecliptic where the plane of the planet's orbit crosses it in passing from S to N and vice versa.

Elongation.—On account of the great eccentricity of Mercury its greatest elongation varies from 16° to 28° east and west and occurs 22 days before and after inferior conjunction or about 36 days before and after superior conjunction.

Conjunction.—These are of two kinds:—inferior and superior,

the former when an inferior planet passes between us and the sun; the latter when the planet has reached the opposite side of the sun from us. In the case of inferior planets they occur twice in each synodic revolution. The inferior occur during retrograde motion, the superior during direct motion.

Opposition and Quadrature.—Neither Mercury nor Venus is ever in opposition because their orbits lie within that of the earth. For a similar reason they never come to quadrature as their elongations never amount to 90° east or west of the sun.

Transits.—Transits of the sun by Mercury occur in May and November. If the orbit were circular they would occur with regularity but on account of the eccentricity the May transits occur near aphelion and are only about half as many as those near perihelion in November. The intervals for May transits are ordinarily 13 or 46 years, while the November transits may come every 7 or 13 years. This is shown by the repetition of synodic periods, 22 of which are equal to almost 7 years, while 41 are nearly equal to 13 years and 145 equal just about 46 years. The last transit was on Nov. 8, 1927, the next will be on May 10, 1937.

Satellites.—Like Venus, Mercury has no lunar attendant. Many very determined efforts have been made to discover one but all have thus far failed. Despairing of the direct observational method, mathematicians have made extended calculations but thus far they have failed to find a satellite.

Life.—We have now been to all the "other worlds than ours" in the solar system and have found no place fit for us to live on or in. No life as we know it, no seasons like ours, so we return to our own planet and in our next article will deal with this the most important of all, Mother Earth.

Lambeth, Ontario

NOTES AND QUERIES

Communications are invited, especially from amateurs. The Editor will try to secure answers to queries.

Photographs of the Planets

In the last issue of the Journal appeared reproductions of photographs of Mars and Jupiter, and of Comet Skjellerup, with its spectrum taken at mid-day; in the present number are further photographs of Mars, Jupiter and Saturn. These truly remarkable pictures were obtained by Mr. E. C. Slipher at the Lowell Observatory, Flagstaff, Arizona. The original photographs, as well as the explanatory notes, were kindly supplied by Dr. V. M. Slipher, the director of the observatory. The editor also received two photographs of Venus taken in 1927 with violet light at the time when the planet showed a crescent phase much like the moon at the age of four days. In these can be seen a dark band near the centre, with brighter areas above and below. This corroborates the fleeting markings sometimes seen visually. Unfortunately the marking is too delicate to be reproduced in a half-tone engraving, which necessarily sacrifices some of the finer details of the original photograph.

For many years the Lowell Observatory has been distinguished for its planetary studies, although it has also made original and very valuable researches in other branches of astronomy.

Reference may also be made here to the neat and clever photographic studies of Prof. W. H. Wright, of the Lick Observatory, his outstanding achievement being the demonstration of a very considerable atmosphere on Mars. In recognition of his brilliant work he has been chosen by the Royal Astronomical Society to be George Darwin Lecturer for 1928, and it is expected that he will deliver his lecture in London in June.

A Bright Meteor

Mr. Wm. H. Schroeder, of Kenosha, Wis., sends the following account of a bright meteor observed on February 12, 1928.

At about 7.20 p.m., C.S.T., the evening being clear and moon-

less, my son Gibbs (age 12) and I were at the telescope (a five-inch refractor which gives us much pleasure) viewing Lamda Orionis, when, just after leaving the eyepiece, a meteor came into view, surprising us so with its brilliancy and suddenness that we almost lost the degree of coolness for observation close enough to justify a report. However the following is, we believe, after close checking, a fair approximation of the circumstances. The object began to glow about midway between Theta and Kappa Orionis, took a course slightly west of south, brushing past and a little to the right (west) of Alpha and Beta Leporis, and then, slackening its speed somewhat, swerved a little to the right (west), diminishing in brightness, but apparently regaining its speed for a moment at least, and became extinct in about 10 or 12 degrees to the West of Alpha Columbae. The first half of its flight was a straight line, the last slightly curved. Time visible about 4 seconds. The colour range seemed considerable, coming in reddish-blue, turning to whitish-blue about half-way through its flight and becoming dull red just before extinction. We feel there was no tail for about the first two-thirds of its flight, but agree that after that a tail about one half degree in length developed. A small piece separated from the main body a moment before the close. The speed I would say was moderate, but its brilliancy was truly impressive, for at its brightest moment I believe it reached three or four times the brightness of Venus when at her greatest brilliancy. I wonder if others who witnessed the phenomena were impressed in the manner we were, and if there is some agreement about our observations, and would be glad to hear from anyone interested.

COMETS IN 1927

In giving a list of advances in Astronomy during 1927 the *Science News-Letter* enumerates the following discoveries of comets:—

An amateur astronomer named Blathwayt, at Braamfontein, South Africa, discovered a new comet on January 13.

An amateur astronomer, William Reid of Rondebosch, South Africa, discovered a new comet on January 26.

The Pons-Winnecke comet, which made one of its sexennial visits to the earth's neighbourhood, was detected on March 3 by

Dr. George Van Biesbroeck, of the Yerkes Observatory, Williams Bay, Wis. It came within 3,500,000 miles of the earth on June 27, closer, with one exception, than any comet had been known to come in the past.

A new comet was discovered on March 10 by Dr. Carl L. Stearns of the Van Vleck Observatory of Connecticut Wesleyan University.

The Grigg-Skjellerup comet was discovered on March 30 by Dr. George Van Biesbroeck, of the Yerkes Observatory.

An Australian justice of the peace and amateur astronomer, Walter F. Gale, discovered a new comet on June 7.

Schaumasse's periodic comet was observed on its return on October 4 by Prof. Van Biesbroeck, of the Yerkes Observatory, and possibly by Gerald Merton, of the British Royal Observatory a little earlier.

Encke's comet, a periodic visitor, was found on November 12, as it came near the earth again, by Prof. George Van Biesbroeck, of the Yerkes Observatory.

A naked eye comet visible in both the northern and southern hemispheres was discovered December 3 by J. F. Skjellerup, Australian amateur, and was visible just before Christmas.

A comet and a nova, or new star, were discovered within three days (Nov. 15 and 18) by two German astronomers, Drs. A. Schwassman and Wachmann.

The Temperature of Mars

At the opposition which occurred in 1926, Mars was very favourably placed for the big observatories in the other hemisphere, and Dr. Coblentz, of the Bureau of Standards, Washington, and Dr. Lampland, of the Lowell observatory, Arizona, took this opportunity to make a careful study of the temperature existing on the surface of the planet. These researches were carried out with the aid of a thermocouple—a most delicate instrument in which the planet's rays, passed through a telescope, heat a tiny speck of blackened metal at the junction of two wires of different alloys, and set up a feeble electric current, which is recorded by a galvanometer. By mounting the thermocouple in a vacuum and making it extremely

small, great sensitiveness can be obtained. One of Dr. Coblentz's thermocouples covered only one-thirteenth of the diameter of Mars.

The heat from the planet comes to us in two types, short waves corresponding to reflected sunlight and long waves emitted from the planet's warm surface. By using special light filters, the different wave-lengths can be separated and their relative heat compared.

The temperatures obtained are influenced by not only our own atmosphere but also that of Mars, but by allowing for these factors, Dr. Coblentz has arrived at the following estimates of the actual surface temperature of Mars. In the south polar region, in its late summer season, the temperature probably ranges from 15° to 50° F.: in the south temperature zone (summer), 65° to 75°.: in the tropics (at noon), 65° to 85°: in the north temperate zone (winter), 30° to 60°: and nearer the north pole, from 10° to 40° below zero. These results differ widely from the views held a few years ago, but as they rest upon actual measurement they afford sufficient grounds for a revision of prevailing opinion. There can now be little doubt that the temperatures on the surface of Mars are much higher than was previously believed, and are quite comparable with those of terrestrial conditions.—(By "Crux Australia" in *The New Zealand Herald.*).

Einstein Again Supported

As is well known Dr. Charles Lane Poor, of Columbia University, is a strong opponent of Einstein's Theory of Relativity. A few years ago he expressed the view that the bending of the light from the stars behind the sun is not due to its passing through the gravitational field of the sun but that it arises from refraction into the cool shadow of the moon in the atmosphere of the earth. He predicted that the angular diameter of the black image of the moon as photographed during a total eclipse would be smaller than at other times.

This has been tested by Dr. Ross W. Marriott and Dr. John A. Miller of the Sproul Observatory, Swarthmore, who after a long series of measurements of their eclipse plates concluded that the diameter of the moon was the same as at other times.

THE SOLAR CONSTANT

For many years Dr. C. G. Abbot of the Smithsonian Institution Astrophysical Observatory, Washington, has been endeavouring to obtain accurate measurements of the sun's radiation and he is undoubtedly the world's leading authority on this subject.

In his Report on the Astrophysical Obsrevatory for the year ended June 30, 1927, he gives some interesting information regarding the progress of the work.

As is well known, he began as assistant to Langley, at Washington. Then he established a station on Mount Wilson and obtained superior results, on account of the clearer sky and the smaller absorption by the atmosphere. But conditions were still not as good as he desired. He wished a clear sky and steady atmosphere for months at a time, and with the assistance of Mr. John Roebling and the National Geographical Society three stations are now in operation which are probably located in three of the very best places on the earth. One is on Table Mountain, Calif. The sky is especially good here during June, July, August and September. In the autumn of 1926 observations were possible on 71 consecutive days. A second station is at Montezuma, in Chile, where rain does not fall once in a decade. This is the best station and daily results are obtained there. The third station is on Mount Brukkaros in South West Africa. Observations began here in December, 1926. From these three stations a continuous daily record of the sun's radiation will be obtained and information from which reliable comparisons of its values may be made will be available.

Dr. Abbot has announced a regular periodicity in the sun's radiation of 25 2/3 months.

The present writer wishes to compliment Dr. Abbot on his persistent efforts and fine achievement in his measurement of the solar radiation; also to congratulate him on his election to the distinguished position of Secretary of the Smithsonian Institution.

TOLSTOY'S ASTRONOMY

"The strand-shooting was capital. Stepan Arkadyevitch shot more birds and Levin two, of which one was not found. It began to get dark. Venus, bright and silvery, shone with her soft light low down in the west behind the birch-trees, and high up in the east

twinkled the red lights of Arcturus. Over his head Levin made out the stars of the Great Bear and lost them again. The snipe had ceased flying; but Levin resolved to stay a little longer, till Venus, which he saw below a branch of birch, should be above it, and the stars of the Great Bear should be perfectly plain. Venus had risen above the branch, and the car of the Great Bear with its shaft was now plainly visible against the dark blue sky, yet still he waited."—From "Anna Karenina," Part II, Chapter 15. (Sent to the editor by a valued correspondent).

THE WINTER SKIES (PSALM XIX)

Clear winter nights are best to trace
The glories of the starlit space,
The whole celestial vault is seen
O'er spread with glowing orbs serene.
In splendour rivalling "The Bear",
Orion with his hounds is there;
Arrayed in panoply of light,
He sheds effulgence o'er the night.
In mythic story we are told
He was on earth a hunter bold
Who fell before Diana's dart,
And then was made of heaven a part.
So long ago he had won fame
That Job and Homer knew his name.
Now Sirius is at his post,
The brightest of the heavenly host.
This star so splendid and sublime
For ages long well marked the time
When Egypt saw the Nile o'erflow
And fertilizing silt bestow.
Fail not to see in this survey
The Galaxy or Milky Way—
A glowing band across the sky
Like gold dust to unaided eye;
So distant that the space atween
Its countless suns can scarce be seen,
In that great dome we have surveyed
We see Almighty power displayed,
And everywhere the reign of laws
Established by the Great First Cause.

78 Chelsea Ave., Toronto. FREDERICK BURROWS.

(The author of these verses is just completing his 86th year. He states that they were suggested by a newspaper report of a lecture by the editor.) C. A. C.

MEETINGS OF THE SOCIETY

AT TORONTO

Jan. 24, 1928.—The regular fortnightly meeting of the Royal Astronomical Society was held in the Physics Building of the University on Tuesday at 8 p.m. Dr. R. K. Young occupied the chair.

Under the heading "Predictions of Phenomena" Dr. Young referred to Pons-Winnecke Comet, which was now visible in the southern hemisphere, as an object of about the 6th or 7th magnitude.

Mr. J. R. Collins announced that hereafter the Society will be—through the courtesy of Sir Frederic Stupart—in receipt of information of any new discoveries; telegrams come to the Meteorological Office, and Mr. Collins will keep the chief officer of the Centre advised.

The chairman then called upon Mr. F. T. Stanford to open the discussion on the subject announced, "Conditions on Mars." Mr. Stanford, by means of a series of charts which he had prepared, called attention to our acquired knowledge of the physical features of the planet. He spoke of the appearance and disappearance of the so-called snow-caps suggesting the melting of ice-fields. Coincident with this was the appearance of straight lines and peculiar markings. Many thought the markings to be broad strips of vegetation produced by water from the melting snow-caps. He referred to the remarkable guess made by Jonathan Swift, who wrote about 200 years ago. Describing the planet as his imaginings pictured it, he said it had two moons and two moons were discovered in 1877 by Hall.

A very interesting discussion followed, in which Mr. H. W. Barker, Mr. H. L. Rogers, Prof. Chant and others took part.

E. J. A. KENNEDY,
Recorder.

AT LONDON

At the Annual Meeting, which was held on Friday, Dec. 9, 1927, the following officers were elected for 1928:

President—H. R. Kingston, M.A., Ph.D.
Vice-President—Mrs. W. F. Boughner.
Secretary-Treasurer—E. T. White, B.A., D.Paed.
Council—Rev. R. J. Bowen, F.R.G.S.; Mr. T. C. Benson; E. H. McKone, B.A., B.Paed.; Rev. W. G. Colgrove, M.A.; Miss N. Morris.

E. T. WHITE,
Secretary-Treasurer.

The Royal Astronomical Society of Canada

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General Treasurer—H. W. Barker, 198 College St., Toronto
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TORONTO CENTRE

Board in charge of meetings: J. R. Collins (Chairman); Dr. J. B. Fraser; R. A. Gray, B.A.; A. R. Hassard, B.C.L.; F. T. Stanford; Dr. W. M. Wunder; E. J. A. Kennedy (Secretary).

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